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# **Physiography of Rice Land in the Chao Phraya Basin of Thailand**

by

Yoshikazu TAKAYA\*

## **Introduction**

Rice cultivation is found in various environments, ranging from mountain slopes to flooded deltaic basins. These rice lands in the Chao Phraya basin have been classified by FUKUI into six categories, based on the simplicity in disseminating new kinds of rice variety.<sup>3)</sup> This paper gives a detailed physiographic description of FUKUI's six types of rice land.

## **I Areal Distribution of Rice Lands**

The six physiographic regions are the intermountain basin, the plugged river channel area, the old delta, the delta flat, the deltaic high and the fan-terrace complex areas. An outline map of their distribution is given in Figs. 1 and 2.

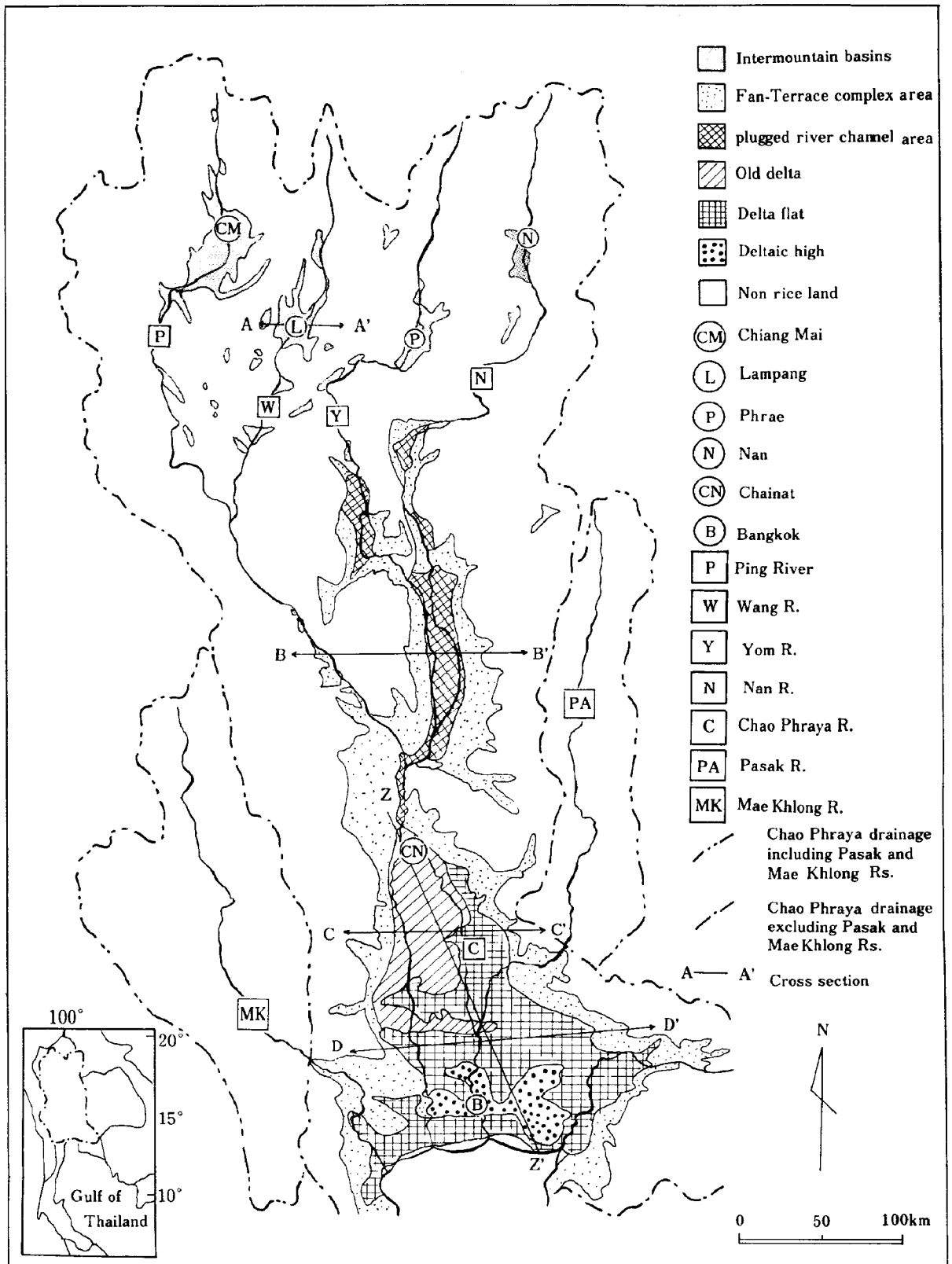
The upper reaches of the Chao Phraya river contain rice lands that developed in small basins surrounded by mountains. These lands can be called intermountain basins. Rice land in the middle reaches of the river can be divided into plugged river channel areas and fan-terrace complex areas. Plugged river channel areas develop as low-lying strips of land along major watercourses, while fan-terrace complex areas occupy gently sloping mountain-foot zones extending along the margin of the Central Plain. The lower reaches of the Chao Phraya river have a deltaic landscape and have three kinds of rice lands corresponding to three physiographic regions, i. e., the old delta, the delta flat and the deltaic high. The area comprising the delta apex region has a comparatively elevated and relieved ground surface and is called old delta in this paper, because it was born in the Pleistocene. A low-lying flat area south of the old delta is divided into two parts according to its ground height; the slightly raised portion near the coast is called the deltaic high, and the rest is the delta flat.

The distribution of the six physiographic regions, and their cross sections, are shown in Figs. 1 and 2. These figures are constructed mainly from two topographic maps of 1 to 50,000 drawn by USAMS<sup>24)</sup> and by RTAMS<sup>18)</sup>. No air photographs were available for this work.

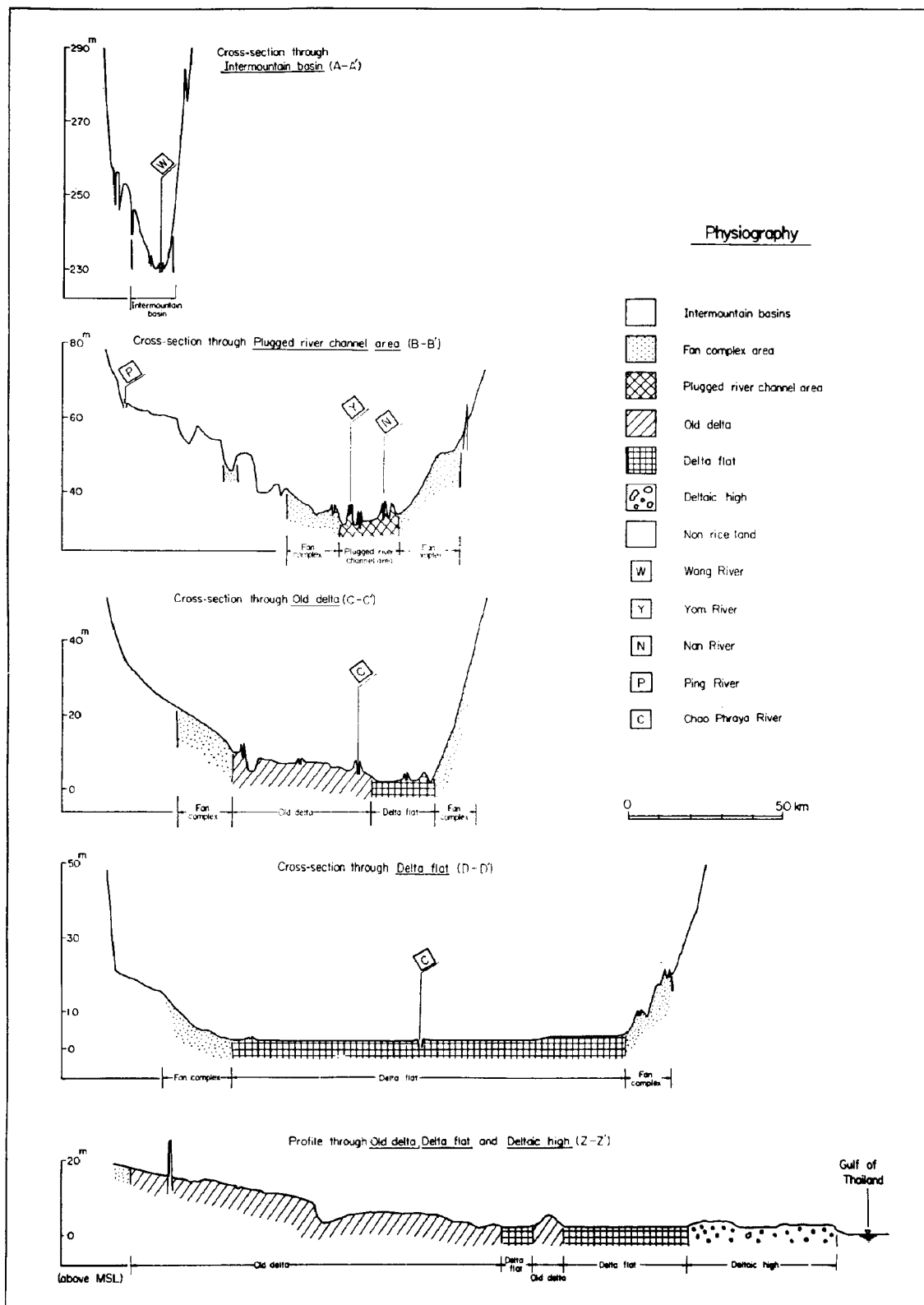
The character of each physiographic region is described below.

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**Fig. 1** Physiographic classification of paddy land of the Chao Phraya river basin  
The cross sections and profile are shown in Fig. 2.



**Fig. 2** Cross-sections and a profile of the Chao Phraya river basin  
The locations are given in Fig. 1.

## II Intermountain Basin

### Physiography

Intermountain basins are situated in North Thailand, and correspond to FUKUI's traditional irrigation areas. They have high elevations, steep general slopes, strong local relief and small areas. The dimensions of a few typical basins can be tabulated as follows:

	elevation(m)	general slope (m/km)*	micro relief	acreage	
				gross**	net***
Chiang Mai Basin	290 — 320	1.7	flat to undulating depending on places	12	10
Lampang Basin	190 — 250	2.0		7	5
Phrae Basin	150 — 170	2.5		4	3
Nam Basin	190 — 210	2.5		2	2

The landforms of an intermountain basin are complex and varied. They may include Recent alluvial plains, Recent fans, fan-colluvial complexes, low and high terraces and Pliocene (?) plains. An example is given in Fig. 3. In the case of the Lampang basin shown in Fig. 3, the Recent alluvial plains and low terraces are dominantly composed of loamy materials with a little sandy constituents of natural levees. The Recent fans are sandy and contain considerable amounts of granules and pebbles. The fan-colluvial complexes are coarser in texture. High terraces are usually capped by thick gravel of cobble size and occasionally are lateritic. Pliocene (?) plains are composed of varying geologic bodies ranging from clayey lacustrine strata to angular gravelly eluvium with various weathering degrees. A more detailed description on geology and pedology of the basin has been given by T. HATTORI<sup>4)</sup>. In these topographic units, most paddy fields develop either on the Recent alluvial plains, low terraces or on the Recent fans.

With respect to the water supply to paddy lands, the intermountain basin is situated ideally. The catchment/paddy area ratio\*\*\*\* is usually large enough to irrigate all of the basins. Moreover, basins have dendric stream networks in their catchment

\*General slope is calculated by a formula,  $(a-b)/l$ , where the a and b are the highest and the lowest elevations in rice land, respectively, and the l is the distance between the two.

\*\*Gross acreage means the acreage of a whole region which is physiographically demarcated.

This is calculated on a 1 to 250,000 topographical map.

\*\*\*Net acreage means the acreage of rice land. This is adopted from H. FUKUI, 1971<sup>3)</sup>.

\*\*\*\*Catchment is the entire area from which drainage is received by an area. The catchment of the Lampang basin, for instance, coincides with the entire drainage area of the Ping river above the southern end of the Lampang basin, while that of the delta flat includes the entire drainage area of the Chao Phraya, Pasak, Bang Pakong and Mae Khlong rivers. These are determined based on the topographical map of 1 : 250,000

area, which effectively carry the rain water of a certain spot in the catchment area into the basin. Mountain climate which accompanies condensation of air moisture also helps the basins to have more chance of rainfall than open valleys or plateaus. These factors can be considered advantageous in growing such a water consuming plant as rice.

Land use

Rice land distribution map indicates that the intermountain basins of Thailand can be considered as a southern extension of the group of intermountain basins of South China. The affinity to South China is suggested by the existence of such traditional agricultural techniques as the Fai-irrigation\* as well.

The current paddy growing relies largely on a modern irrigation system, which is in principle the same as the Fai-irrigation system. Canals in the Lampang basin, for example, are illustrated in Fig. 4. The water of the Wang river is dammed up at the entrance to the basin and distributed into many parts of the basin through main and feeder canals. The moderate size and moderate general slope of the basins help such gravity irrigation to work efficiently.

Though the canal irrigation commands a dominant portion of the basin, other types of water supply can also be seen. For instance, shallow wells mobilize rich ground water in the Recent fans on the right bank of the Wang. The wells are primarily for winter upland crops but some are used for rice crops too. Besides the canals and wells, patches of rain-fed fields with primitive ditches are found along mountain foots. Generally speaking, the canals supply water to recent alluvial plains and low terraces, the wells to the Recent fans, while the rain-fed paddy fields are located on the fan-colluvial complexes and on the Pliocene plains within the basin.

### **III Plugged River Channel Area**

#### Physiography

The plugged river channel area corresponds to FUKU's inland flood area.

This area forms low depressional stretches along the Nan and the Yom rivers, with an average width of ca. 20 km. The elevation ranges from 23 m above MSL at the downstream end to 60 m at the uppermost end. The general slope is ca. 0.2 m/km along its N-S axis. Despite the gentle general slope, the local relief reaches a height of more than 5 m because of the webs of natural levee and backswamp.

The area has an extremely high stream density, as shown in Fig. 5. Geomorphologically this can be termed as a Recent alluvial valley<sup>5)</sup>, in which shiftings of silt laden river courses are very common. The most decisive character, however, is that the valley has a bottle-neck like gorge at its downmost reach. Floods are plugged here, causing deep and prolonged inundation. The plugged river channel area is thusly named because of this particular phenomenon.

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\*A diversion irrigation dam made of bamboo and brushwood

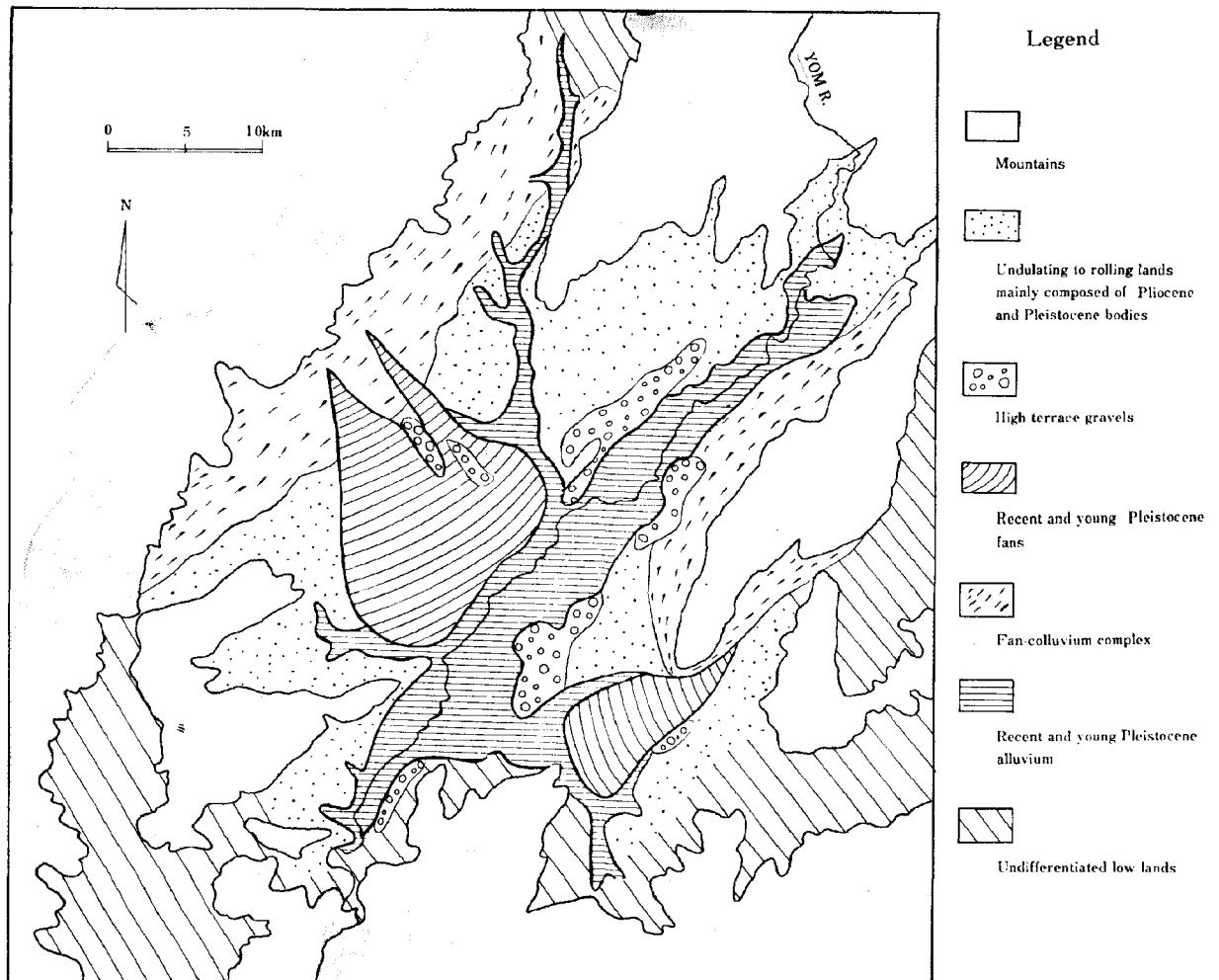
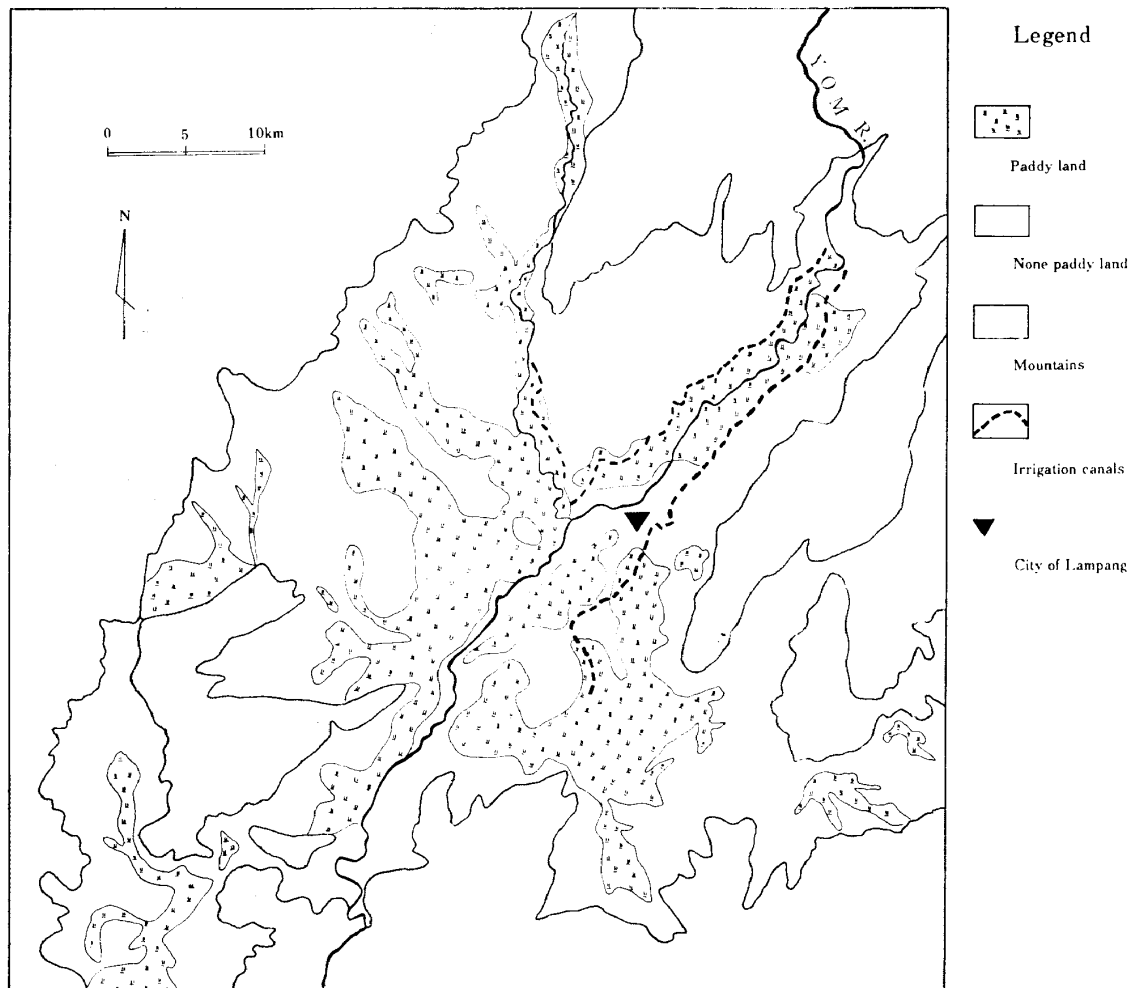


Fig. 3 Geomorphological sketchmap of the Lampang basin

The catchment/paddy area ratio is 32.8. This enormous ratio, together with the trough like depressional position and the gorge, causes the valley to suffer heavy flooding. Every year, the water level raises very rapidly after the first rain of wet season and keeps a high level long after the end of the rainy season, leaving only elevated natural levees above the water. No means of quick drainage is known except for pumping out. Slow run off from the bottle neck is and will be the only reliable way of lowering the flood level.

#### Land use

Because of the deep and prolonged flooding during the rainy season, available land for human occupation is limited to natural levees. Fig. 6, which is a map of a part of the area as of 1915, shows how exclusively houses were concentrated on levees. Of many levees, those along active river courses were preferred, because of the convenience of transportation by means of water. Paddy growing was done in the nearby backswamp areas which were easily accessible from the villages on levees. An inter-



**Fig. 4** Distribution of paddy fields in the Lampang basin

esting thing is that the paddy growing was thus, made in depressional spots rather than elevated lands even in this easily flooded valley. Fig. 7 is a map of a survey made in 1957. The similar type of land use is seen here too. After occupying the entire levees along active channels, people likely expanded their fields to levees along minor or abandoned channels as well as paddy fields in the adjoining backswamp areas.

The area's absolutely low elevation, however, will act as a crucial handicap in the course of intensifying the land use. Sophisticated water control is next to impossible on this trough. Moreover, once large irrigation schemes are adopted on the adjoining areas, the valley is apt to be compelled to play the role of a trash box area.

#### IV Old Delta

##### Physiography

The old delta corresponds to the barrage irrigation area in FUKUI's classification.

The area has a deviated fan-shaped configuration, having the apex at Chai Nat. The radius is ca. 100 km and the arc is ca. 70 km long. The elevation attains 20 m



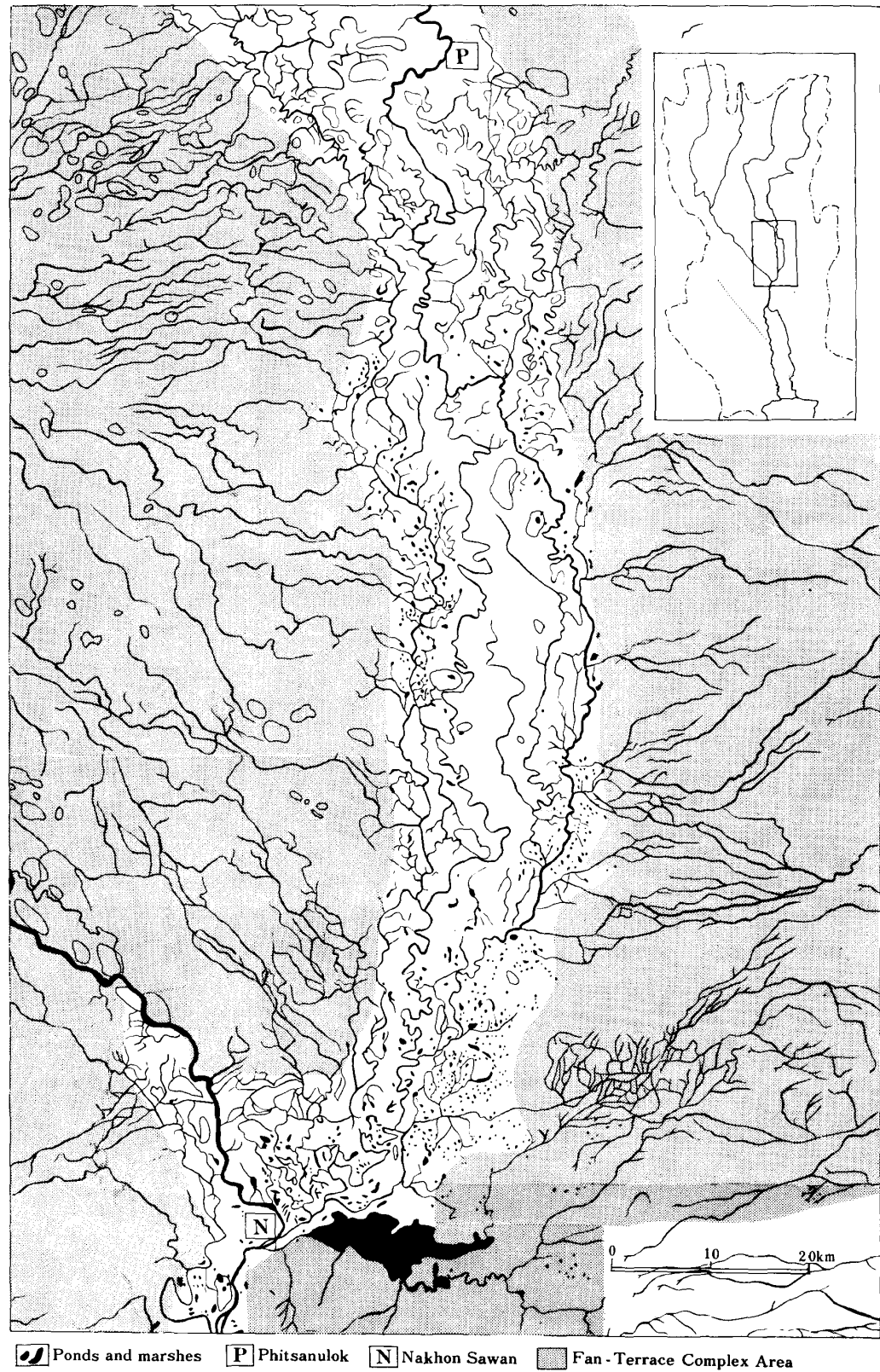
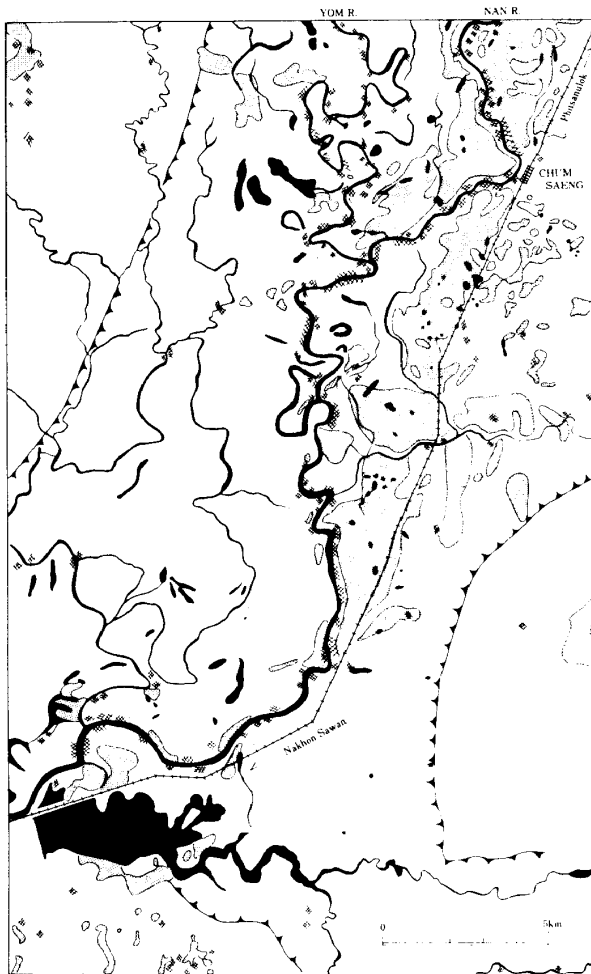


Fig. 5 Typical stream patterns of the plugged river channel area

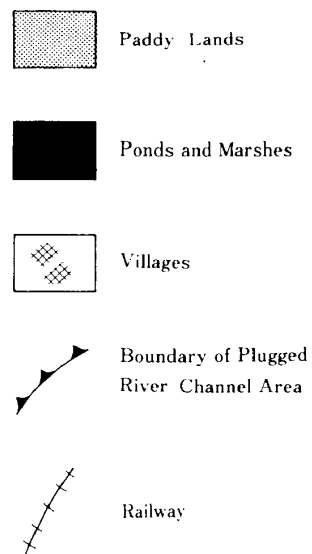
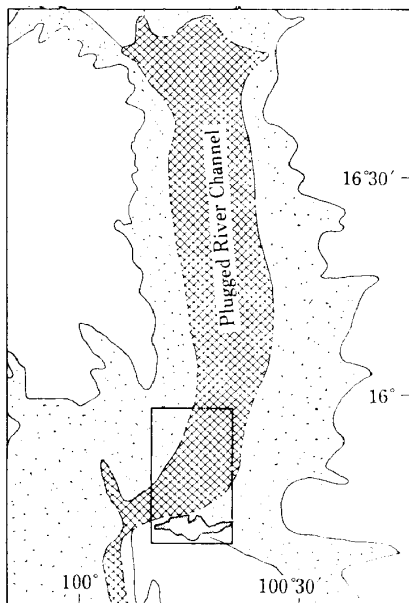


**Fig. 6** An example of land use in the plugged river channel area as of 1915



**Fig. 7** An example of land use in the plugged river channel area as of 1957

Index map for Figs. 6 & 7



near the apex and lowers to 5 m near the arc. This is lower than the adjoining fan-terrace complex areas but higher than the delta flat. The general slope is ca. 0.15 m/km along the N-S direction. The local relief reaches to more than 5 m.

Geomorphologically the area is defined as an Upper Pleistocene delta<sup>19)</sup>, partially superposed by Recent levee deposits<sup>22)</sup>. The fan-like shape and the gentle general slope can be ascribed to the deltaic origin of this geological body, whereas the strong local relief is explained by the co-effect of the normal dissection on the Pleistocene surface and the superimposition of the Recent levees. Another characteristic feature is ubiquitous bifurcations of streams, which provide the area with the webs of swell and swale oriented parallel to the ribs of the delta. The bifurcated channel system is the vestige of the Pleistocene distributaries of the delta. These geomorphic characters are well reflected on a flood distribution map of Fig. 8. Chains of deeply flooded spots are shown occupying the swales.

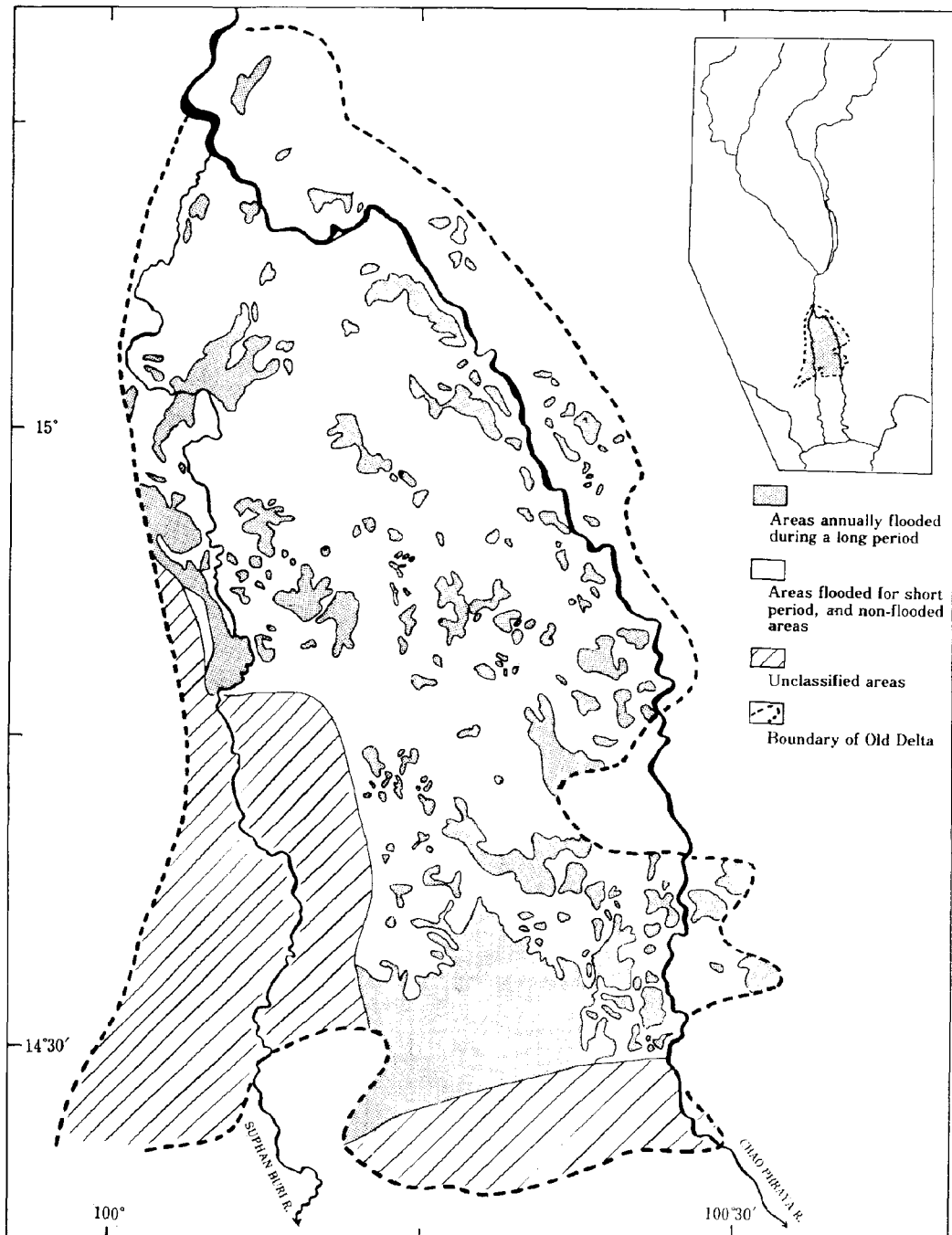
The physiographic peculiarity of the area is used to the best advantage in the layout of irrigation and drainage networks. One trunk river, the Chao Phraya river in this case, flows down to the apex and bifurcates repeatedly to form a network of spreading distributaries. If we construct a barrage at the point of the first bifurcation and set feeder canals on the levees of the distributaries, the whole area could be irrigated easily by gravity. The greater Chao Phraya Project, which is a large scale irrigation and drainage project covering the whole of the old delta, is actually based on this idea<sup>1)</sup>. Fortunately the ground surface has enough relative height and local relief to drain the water from the thus irrigated land. NEDECO estimates that if the system is managed skillfully, 60 % of the whole area may be perfectly water-controlled, the rest, 40 % of the depressional plots, remains as a conservation irrigation area.

The catchment/paddy area ratio is 23.0. If a barrage or a dam had enough capacity to hold most of the runoff of rainy season, the area would be safely irrigated even during the dry season.

#### Land use

The old delta is thought to be one of the earliest inhabited areas in the Central Plain of Thailand, as is suggested by a few Dvaravati remain (provisionally supposed from 7 C. to 11 C. AD). Not only the long occupation, but the area had been holding the position of the political as well as economical center of Thailand for more than 500 years until the Bangkok plain appeared suddenly as a profitable rice plantation area in the 1850's.

The land use pattern of the bygone days can be seen on a map shown in Fig. 9, which is a work of the 1910's. Here, a fairly large area is still covered by grass, bamboo and trees, only restricted depressional plots being used as paddy fields. Fig. 10 is a map of the same area as of 1957. The paddy fields have expanded greatly, but elevated parts are still left uncultivated. Fig. 11 is a land suitability map in terms



**Fig. 8** Distribution of swales which are flooded annually for a prolonged period

Fig. 8 is compiled from the soil survey reports prepared by the Land Development Department, Ministry of National Development, Thailand<sup>(7-15)</sup>.

According to the reports, the flooding condition is divided into five classes as follows;

- Class a: Flooded during most of the year
- Class b: Periodic flooding with prolonged duration
- Class c: Periodic flooding during a short time
- Class d: Flooded only during exceptional high floods
- Class e: Never or very seldom flooded

The "Areas annually flooded during a long period" shown in Fig. 8 include the classes a and b, while the "Areas flooded for short periods, and non-flooded areas" include the classes c, d and e.

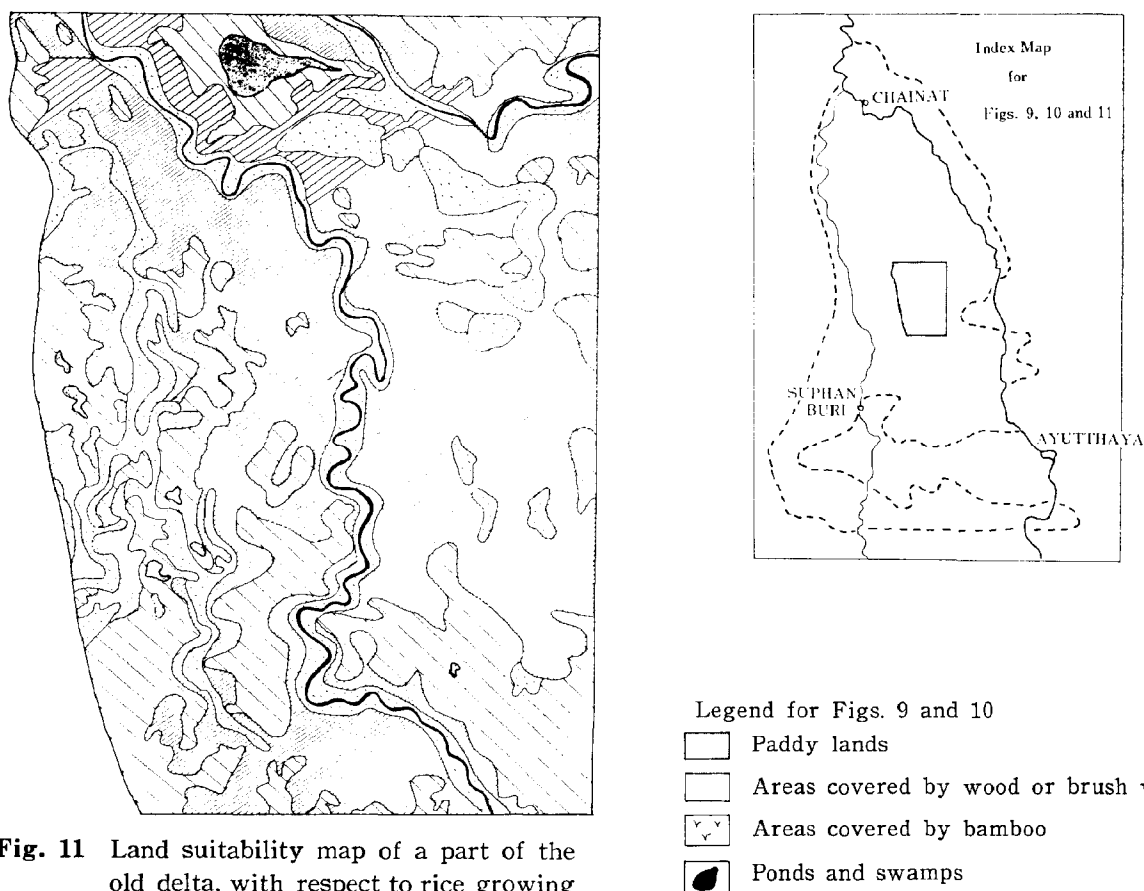


**Fig. 9** Distribution of paddy fields in the old delta as of 1919



**Fig. 10** Distribution of paddy fields in the old delta as of 1957

of rice cultivation in expectation of the success of the Greater Chao Phraya Project. On this map, portions which are classified as "lands to be used for rice with irrigated dry-land crops as a secondary crop in the dry season" correspond to the NEDECO's perfectly water-controlled areas of higher elevation. The comparison of the three maps indicates an interesting thing. That is; the early developed plots are all in depressional positions, and this preference of low lying spots over elevated parts lasts as long as the irrigation technique remains at primitive level; however, once a modern irrigation scheme is introduced, the prior choice shifts to the elevated parts which have been considered as barren before. Actually the change takes place at the sacrifice of the traditional rice lands in the depressions, because these places are expected to act as dumping basins. TOMOSUGI<sup>23)</sup>, who discussed the development of the irrigation works in the Chao Phraya delta, stressed this point. KAIDA's careful analysis<sup>6)</sup> of the effect of the environmental factors on rice yields in the Greater Chao Phraya Project area also suggests the similar conclusion. The reversing of the relative values induced by the introduction of modern irrigation scheme appears to be a striking event in the history of the old delta's development.



## VI Delta Flat

### Physiography

The delta flat corresponds to FUKUI's canalled lowland.

The delta flat, together with the deltaic high, comprises the so-called Mae Nam Chao Phraya delta, in which a relatively low-lying portion or an area having lower elevation than 2 m above MSL is named the delta flat. The area has an indented outline with maximum N-S length of ca. 180 km and an acreage of  $1.1 \times 10^4$  km<sup>2</sup>. The general slope is 0.01 m/km, and the local relief is nearly nil.

Physiographically, the delta flat is defined as interdistributary basins on the Recent delta dominated by brackish environment, with a monsoon climate. This physiographic setting controls all nature of the delta flat. The downstream area of the big river in monsoon regions inundates deeply during the rainy season and changes to

parched terrains during the dry season. Though the cycles are occasionally disturbed by fickle tropical storms, the general pattern of the flooding regime is repeated regularly. Monsoon deltas are, thus, a kind of amphibious terrain; it is neither land nor water.

The monsoon climate is one factor causing the amphibiousness. But the amphibiousness also roots in another source; it roots in the soil mechanical properties of the deltaic sediments. Very often young deltas cannot support even their dead loads. Self-consolidation occurs in the substrata even under normal conditions, and the ground surface subsides differentially depending on the condition of the subground structure and stress. A less flooded plot of ten years ago is often found as a deeply flooded swales today, and this may again transform to a non-flooded swell in the years from now because of the differential vertical movement of the delta surface. In the range of ten years, the relative movement was often recorded to reach more than one meter. Figs. 12 and 13 demonstrate how the delta flat changed in a short period. An area which was once a beautiful paddy land in 1914 is seen as a swampy waste land in a map as of 1957. Recent deltaic surface may be described as an unstable low land with a large number of wandering marshes and swamps.

The depositional environments in which the delta flats were formed result in another peculiarity. The brackish to hypersaline depositional environment contributes in concentrating iron sulphide in the sediments. A very extensive distribution of acid sulphate soil in the area can be ascribed to the brackish environment in which the sediments deposited.<sup>16)</sup>

#### Land use

Vast land with ubiquitous swamps must be the most troublesome terrain to develop. The delta flat, thus naturally, had been left untouched until it received a very strong impact from outside. It was in the 1850's that people found rice was becoming a profitable export food and started the reclamation of the land.

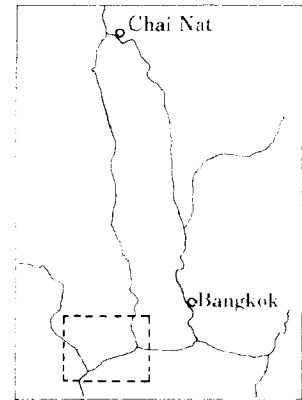
For the reclamation it was necessary to secure a perennial means of access into the area. The best way was to canalize the whole area. The delta flat under reclamation is seen in Fig. 14, a map as of 1915/6. In the map, a considerable area near the northeastern corner of the delta flat is still covered by grass land, in which only narrow strips along natural and dug channels are used as paddy fields. Today all the delta flat, except for the gulf facing a narrow zone, is seen to have been changed to a boundless expanse of paddy fields.

The next step of the development might be a kind of land consolidation for a more intensive land use. This, however, would be far more difficult to achieve than the mere canalization of the area. The reason is that the water control in such an extremely low lying area is possible only either by building flood protecting levees along rivers or by making a polder of the paddy fields, but it is quite doubtful if such embankments pay on this troublesome foundation. To cope with the formidable



**Fig. 12** Distribution of paddy fields and hypersaline plants in a part of the delta flat as of 1914

Index map for Figs. 12 and 13



Legend for Figs. 12 and 13

Ponds and marshes

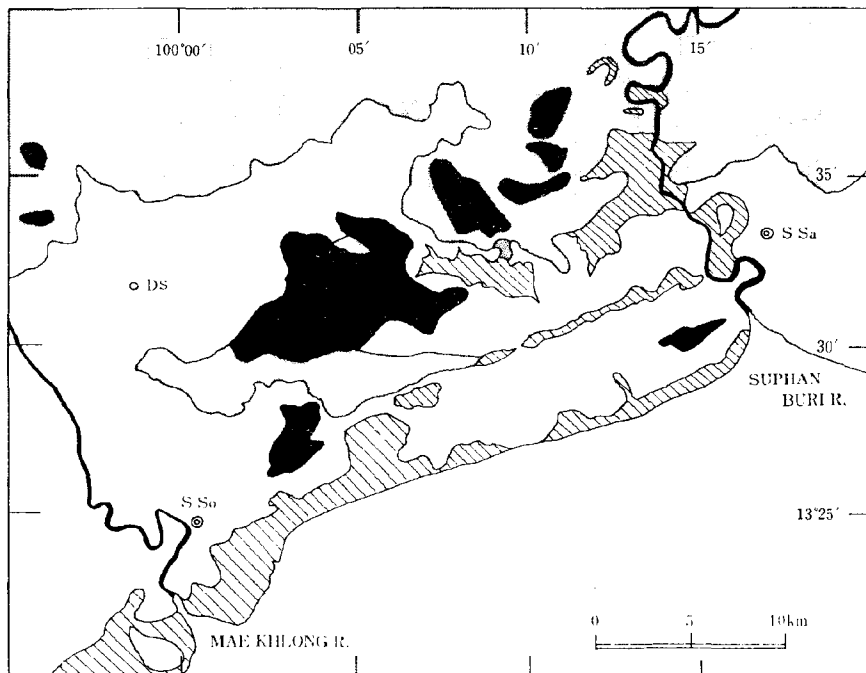
Paddy fields

Brackish and hypersaline plants

S Sa : Samut Sakhon

S So : Samut Songkhram

DS : Damnoen Saduak



**Fig. 13** Distribution of ponds and marshes, paddy fields and hypersaline plants in the same region as Fig. 12, as of 1957

differential subsidence of the bank's foundation, an unexpected amount of money would be required for the maintenance expenses. It appears to be a natural trend that the delta flat will be increasingly and intensively utilized, adopted by more and more



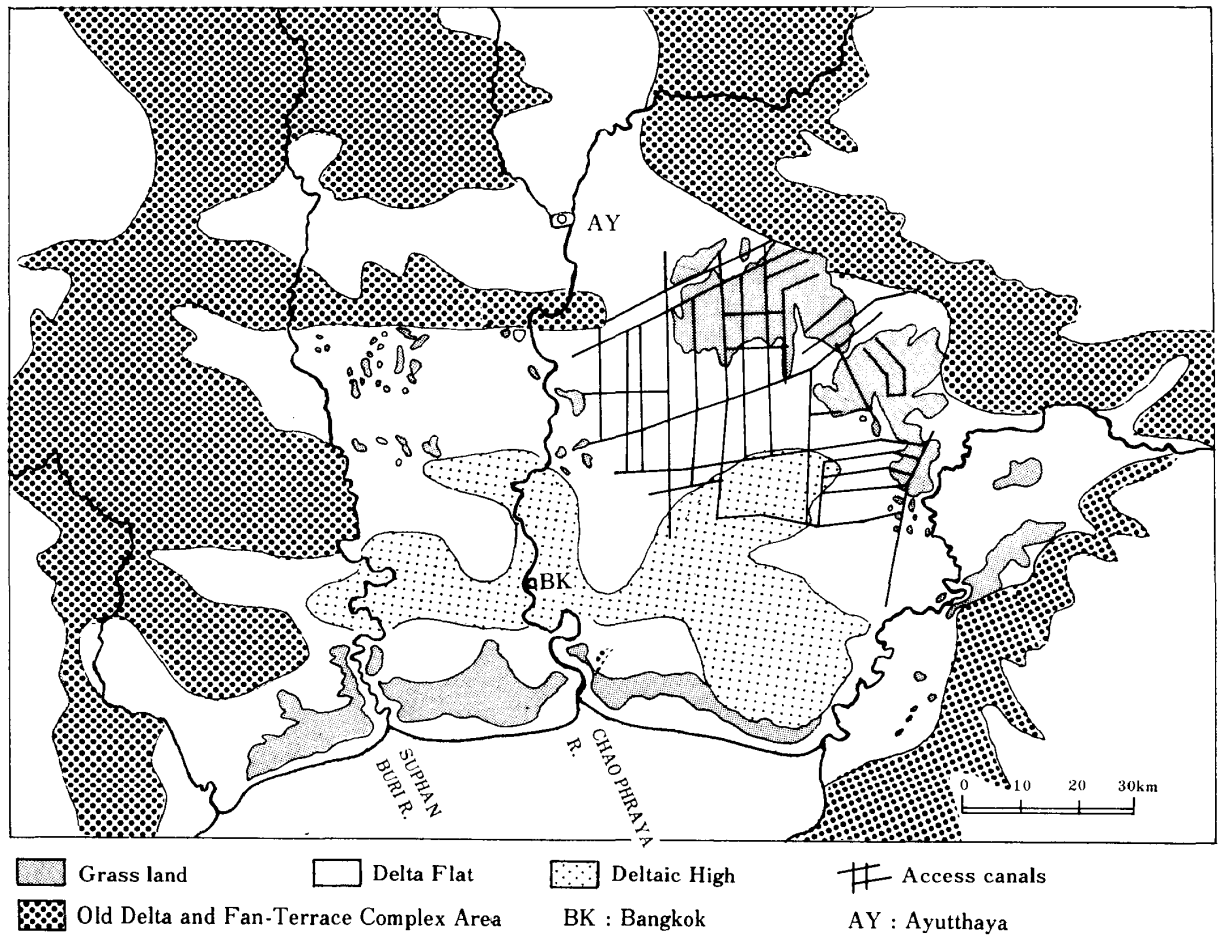


Fig. 14 Distribution of grass lands in the Recent deltaic region of the Chao Phraya as of 1915/6

intricated agricultural techniques. The intensification will be done profitably only with a thorough understanding of the deltaic character, especially its amphibiousness.

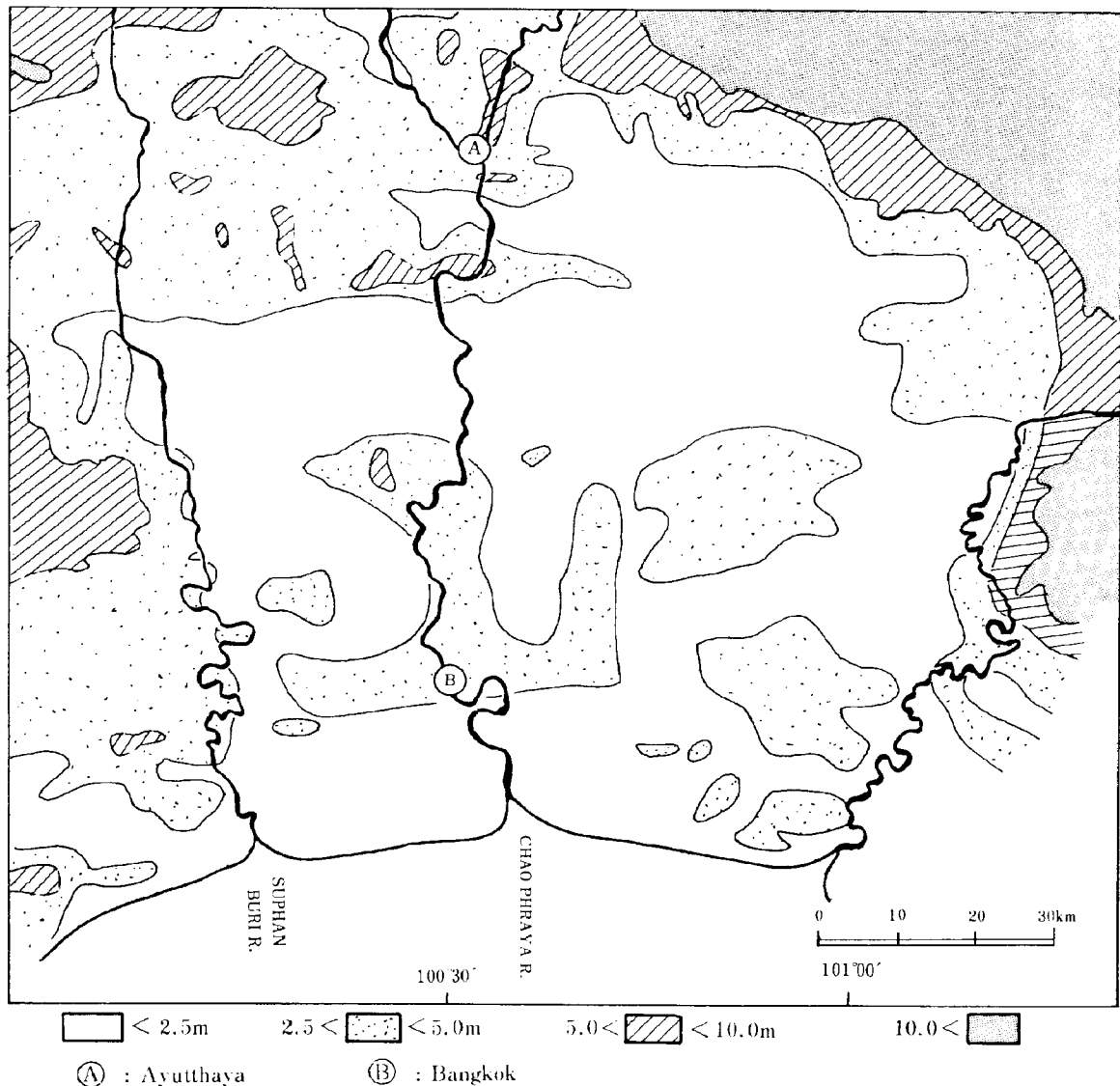
## VII Deltaic High

### Physiography

The deltaic high corresponds to FUKUI's less flooded delta.

These are slightly elevated parts in the Recent deltaic plain. The ground height averages 3 m, which is about 1 m higher than the average height of the delta flat, but occasionally attains 5 m. The general slope is in the order of 0.01 m/km. The local relief is very slight, though it is stronger than that of the delta flat. The area holds an acreage of ca.  $2 \times 10^3$  km<sup>2</sup>. The topographic relationship with the delta flat can be seen in a contour map shown in Fig. 15.<sup>20)</sup>

Though the area is apparently a part of the Recent delta, its detailed geomorphological nature is unclear. Probably the area is aggregates of elevated lands of various geneses. For instance, an E-W elongated strip on which Bangkok is situated



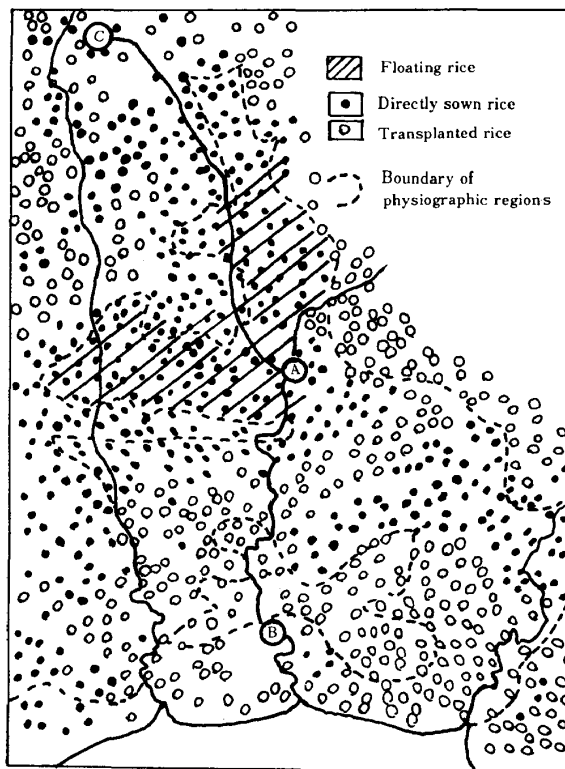
**Fig. 15** Contour map of the Bangkok Plain; constructed based on the AMS's topographical map of 1:50,000 surveyed in 1957

seems to be an old barrier or a beach ridge, while a broad elevation west of the Bang Pakong river looks like a complex of natural levees produced by the river. Some portions may have been formed by the relative local uplifting due to differential consolidation.

Disregarding the genesis, the deltaic high has a conspicuous physiographic dissimilarity to the delta flat; the former has a higher ground elevation and a denser stream density than the latter. And these topographic conditions help the former area to keep its flood depth shallower and to drain water more quickly.

#### Land use

Fig. 16 is a map showing the distribution of broadcasted and transplanted rice fields in the delta region. The physiographic divisions are well reflected on the



**Fig. 16** Distribution of floating rice, directly sown rice and transplanted rice in the deltaic region of the Chao Phraya; modified from Takaya, Y(1969)<sup>21)</sup>

growing methods; the deltaic high is absolutely and dominantly covered by transplanted rice, whereas the delta flat is by broadcasted rice. Apparently the flood depth and the drainability are the determining factors.

Another physiographic control over the rice culture is seen in the average area of cultivated land per farm house. A census of agriculture in 1963<sup>17)</sup> gives information to conclude roughly that the average holding per family is 20 to 35 "rai"\* per farm house on the deltaic high while it is more than 35 "rai" on the delta flat.<sup>21)</sup>

## VIII Fan-Terrace Complexes Area

### Physiography

The fan-terrace complex area corresponds to FUKUI's water deficient foothills.

The fan-terrace complex areas develop, forming piedmont topography, along the marginal parts of the Central Plain of Thailand, merging from the plain proper to the mountain ranges. The general slope ranges from 1.0 m/km to 2.5 m/km. The local relief is usually strong. Streams inside the area almost 10 m deep. The total acreage is estimated to be ca.  $1.8 \times 10^4$  km<sup>2</sup>.

The dominant part of this area is composed of Recent and Upper Pleistocene fans. As is common in normal fan regions, the area shows the evidence that the shifting of stream channels across the ground surface has been frequent. Streams are more or less straight and short. And active drainage lines are usually deep near the mountain but shallow downslope and occasionally vanish. These characters give the area somewhat desolated landscapes.

Because the area is a complex, it can be parcelled into many small fans and terraces of different nature. The difference results primarily from the geology of the corresponding hinterlands. For instance, a fan with its catchment in a shale-dominated region, must be rich in clayey fractions and nutrient, while another fan gathering water from arkose sandstone region must be coarse textured and poor. Based on this idea, the whole fan-terrace complex area may be classified in terms of poten-

\*1 rai=0.16 ha.

tial fertility. In Fig. 17 is given a very rough classification of the area in this respect. The hinterland geology is, of course, not the only determining factor of the fertility. A better fertility level map could be constructed by taking such factors as the climate and the age of the ground surface into account.

Hydrographically, the area cannot be said to be favorably situated. The catchment/paddy area ratio is as small as 5.1, and streams are all short and steep. This results in torrential flashes rather than steady flows. Another disadvantage comes from its porous substrata which allow rapid sinking of water into the ground. The water available thus tends to be unstable and deficient. The water deficient foothill by FUKUI's classification, is named because of this hydrographic nature.

#### Land use

Though the area appears rather desolated, a relieved and sloped terrain is ecologically a varied land by comparison with a flat monotoneous land. People seem to have found suitable plots to grow food in this area since long ago, if only in very much restricted plots. Archaeology suggests that the fan-terrace complex area is one of the earliest inhabited areas in Thailand. The most likely history of the development is that ancient people had settled down in the best spots near the foots of the fans and extended their domains upslope along braided streams, using the streams as natural feeder canals. The layout of paddy fields thus reclaimed is seen typically in Fig. 18.

The crucial limitation for paddy culture on the area comes from its absolutely small catchment/paddy area ratio. The capricious flow regime doubles the disadvantage. The fact that both planted and harvested acreages change from one year to another is ascribed to these hydrographic characters. This disadvantage cannot be overcome as far as the rice growing relies on the stream runoff only. The only way to solve the problem is to utilize water of the main distributaries of the Chao Phraya river. It is said that if barrages are constructed on main tributaries of the Chao Phraya river and the water is carried from them to the upper slopes of the fan-terrace complex area, the area will be effectively and constantly irrigated (personal communication with Dr. Y. KAIDA of Kyoto Univ.). Topographically, the area is gravity irrigable potentially. Once a fairly large initial investment is made for the proposed irrigation system, its maintenance would be rather easy.

### Summary

The paddy land of the Chao Phraya river basin in Thailand is classified physiographically into six divisions, i.e., the intermountain basin, the plugged river channel area, the old delta, the delta flat, the deltaic high and the fan-terrace complex area. These divisions correspond to FUKUI's six categories of rice land<sup>3)</sup> which are primarily proposed to evaluate the feasibility of dissemination of a new variety of rice.

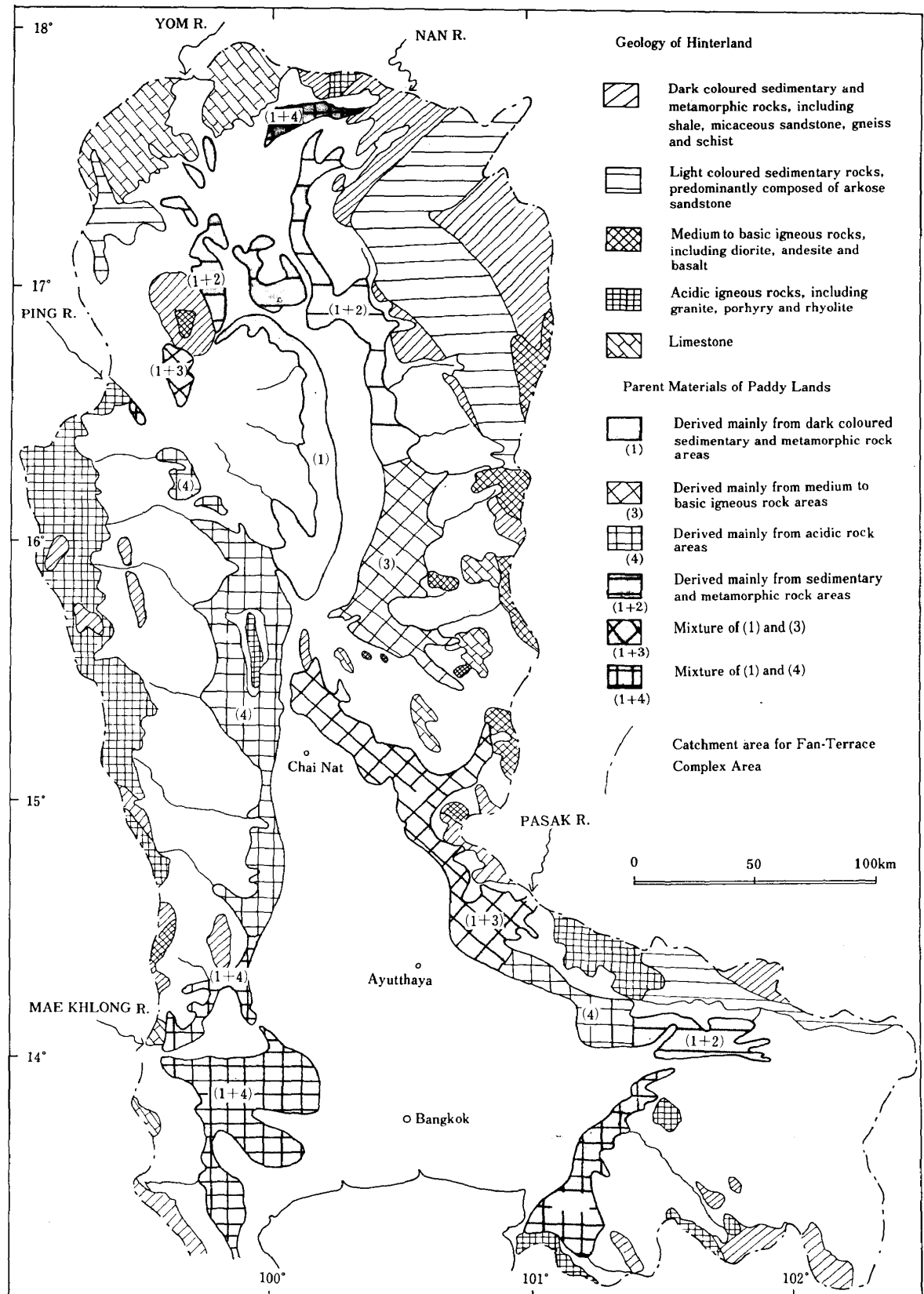


Fig. 17 Provisional subdivision of the fan-terrace complex areas with respect to the geology of the hinterland

**Table 1** Characteristics of the six physiographic regions and correlation with Fukui's categories

Physiographic regions	Elevation (m.above M.S.L)	General slope (m/km)	Local relief (m)	Acreage × 1,000 ha		Soil Texture	Geomorphic setting	Catchment Paddy area ratio	Fukui's Categories
				Gross*	Net**				
Intermountain Basin	150 - 350	1.7 <	<10	250	200	Clay to gravelly sand	Complex of stream alluvium, fan and terraces	10~40	Trasitional irrigation area
Plugged River Channel Area	23 - 60	0.2	± 5	320	200	Clay with a little sand	Recent alluvial plain	32.8	Inland flood area
Old Delta	5 - 20	0.15	< 8	490	400	Clay with a little sand	Upper Pleistocene delta	23.0	Barrage irrigation area
Delta Flat	0 - 2	0.01	negligible	1110	820	Clay	Interdistributary low of Recent delta	15.6	Canalled lowland
Deltaic High	2 - 4	0.01	negligible	210	160	Clay with a little sand	Relatively elevated parts in Recent delta		Less-flooded delta
Fan-Terrace Complex Area	5 - 100	1.0 - 2.5	<10	1800	1350	Sand with a little clay and gravel	Recent and Pleistocene fans and terraces	5.1	Water deficient foothills

\* and \*\* : see the foot notes on page 378

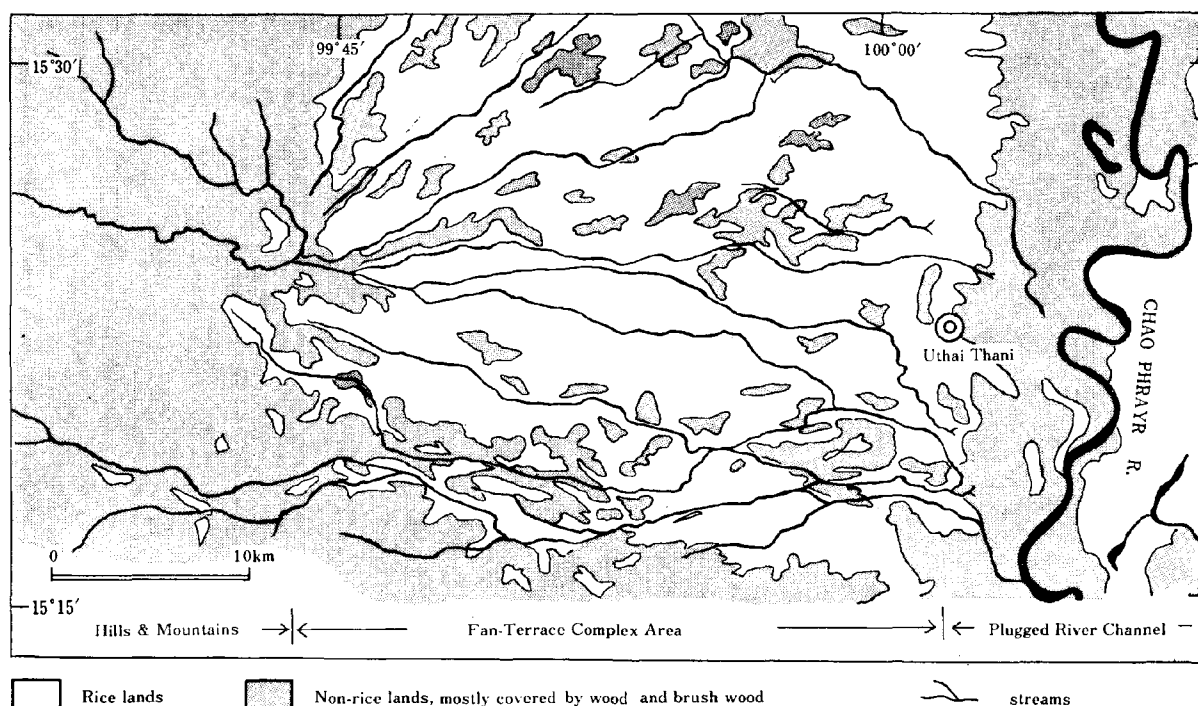


Fig. 18 Distribution of paddy lands in a parcel of the fan-terrace complex area.

The description of the nature of each physiographic region and the correlation with FUKUI's category are concisely given in Table 1. The distribution of the six regions and their cross sections are as shown in Figs. 1 and 2.

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